

CLAIMS

We claim:

1. A method for fabricating a progressing cavity stator, the method comprising:

(a) providing a first core having at least one helical groove on an outer surface thereof;

5 (b) disposing a plurality of fibers in each helical groove to form a fiber preform;

(c) inserting the fiber preform into a cylindrical tube;

(d) injecting a resin into the cylindrical tube to form an impregnated fiber preform;

10 (e) removing the first core from the impregnated fiber preform thereby forming an internal helical cavity in the impregnated fiber preform;

(f) inserting a second core having at least one helical groove on an outer surface thereof into the internal helical cavity of the impregnated fiber preform, the second core having a smaller diameter than that of the first core, thereby forming a substantially helical annulus between the second core and the impregnated fiber preform;

15 (g) injecting an elastomeric material into the helical annulus; and

(h) removing the second core.

2. The method of claim 1, wherein the first core comprises a number of helical grooves in a range from two to about ten.

3. The method of claim 1, wherein fibers among the plurality thereof are selected from the group consisting of fiber roving, woven fibers, non-woven fibers, braided fibers, braided fiber bundles, fiber bundles, fiber bundles wrapped in a braided fiber tube, chopped fibers, stitched three-dimensional fabrics, and combinations thereof.

4. The method of claim 1, wherein fibers among the plurality thereof are selected from the group consisting of glass fibers, carbon fibers, aramid fibers, boron fibers, polyester fibers, polyethylene fibers, and combinations thereof.

5. The method of claim 1, wherein (b) comprises disposing fibers on the first core such that distinct portions of the fibers follow correspondingly distinct directions.

6. The method of claim 1, wherein (b) comprises disposing fibers on the first core such that distinct portions of the fibers are intertwined and follow correspondingly distinct directions.

7. The method of claim 1, wherein (b) further comprises:

(1) disposing a braided fiber layer about the first core;

(2) disposing one or more braided fiber tubes in each helical groove; and

(3) securing the braided fiber tubes in the helical grooves with fiber

5 windings deployed circumferentially around the braided fiber tubes.

8. The method of claim 1, wherein (b) comprises disposing a three dimensional fiber strand in each helical groove about the first core, each three dimensional fiber strand having a profile substantially complementing its corresponding helical groove.

9. The method of claim 1, wherein the cylindrical tube in (c) comprises an inner diameter substantially equal to an outer diameter of the fiber preform;

10. The method of claim 9, wherein the inner surface of the cylindrical tube is substantially coated with a mold release compound.

11. The method of claim 1, wherein (d) comprises vacuum assisted resin transfer molding.

12. The method of claim 1, wherein at least one of the first core and the second core include a tapered outer diameter along a length thereof.

13. The method of claim 1, further comprising:

(i) separating the impregnated fiber preform from the cylindrical tube.

14. The method of claim 13, further comprising:

(j) machining an outer surface of the impregnated fiber preform.

15. The method of claim 14, wherein (j) comprises machining at least one groove on the outer surface of the impregnated fiber preform, each groove sized and shaped for engagement with a corresponding key deployed on an inner surface of a stator tube.

16. A replaceable progressing cavity insert for a stator, the replaceable insert comprising:

a fiber reinforced composite component providing an internal helical cavity, the fiber reinforced composite component having an internal surface, the internal surface having at least one helical groove provided thereon;

an elastomeric liner disposed on the internal surface of the fiber reinforced composite component; and

the insert having an outer surface, the outer surface sized and shaped for removable receipt within a cylindrical tube.

17. The replaceable insert of claim 16, wherein the cylindrical tube is couplable with a drill string.

18. The replaceable insert of claim 16, wherein:

the outer surface provides at least one longitudinal groove;

an inner surface of the cylindrical tube includes at least one corresponding longitudinal key; and

each corresponding pair of longitudinal grooves and keys is sized and shaped for selective engagement and disengagement during said removable receipt of the insert in the cylindrical tube.

19. The replaceable insert of claim 16, wherein the outer surface is sized and shaped for removable press fitting within the cylindrical tube.

20. The replaceable insert of claim 16, wherein distinct portions of the plurality of fibers follow correspondingly distinct directions.

21. The replaceable insert of claim 16, wherein distinct portions of the plurality of fibers are intertwined and follow correspondingly distinct directions.

22. The replaceable insert of claim 16, wherein fibers among the plurality thereof are selected from the group consisting of fiber roving, woven fibers, non-woven fibers, braided fibers, braided fiber bundles, fiber bundles, fiber bundles wrapped in a braided fiber tube, chopped fibers, stitched three-dimensional fabrics, and combinations thereof.

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23. The replaceable insert of claim 16, wherein fibers among the plurality thereof are selected from the group consisting of braided fibers and braided fiber bundles.

24. The replaceable insert of claim 16, wherein fibers among the plurality thereof are selected from the group consisting of glass fibers, carbon fibers, aramid fibers, boron fibers, polyester fibers, polyethylene fibers, and combinations thereof.

25. The replaceable insert of claim 16, wherein the matrix material comprises an epoxy resin.

26. The replaceable insert of claim 16, wherein the elastomeric liner has a non-uniform thickness, the non-uniform thickness varying in directions of at least one of parallel to a cylindrical axis of the replaceable insert and radially about the cylindrical axis.

27. A progressing cavity stator comprising:

a substantially cylindrical tool body having a cylindrical axis and two ends;

a fiber reinforced composite component disposed in the tool body substantially coaxially with the cylindrical axis, the fiber reinforced composite component providing an internal helical cavity, the fiber reinforced composite component having an internal surface, the internal surface having at least one helical groove provided thereon;

an elastomeric liner disposed on the internal surface; and

the elastomeric liner having a non-uniform thickness, the non-uniform thickness varying in directions of at least one of parallel to the cylindrical axis and radially about the cylindrical axis.

28. The progressing cavity stator of claim 27, wherein the thickness of the elastomeric liner increases in a direction parallel to the cylindrical axis from one end of the tool body to the other end of the tool body.

29. The progressing cavity stator of claim 27, wherein the elastomeric liner includes a substantially periodic thickness variation radially about the cylindrical axis.

30. The progressing cavity stator of claim 27, wherein the fiber reinforced composite component comprises a plurality of fibers disposed in a matrix material, the plurality of fibers disposed such that distinct portions thereof follow correspondingly distinct directions.

31. The progressing cavity stator of claim 30, wherein the distinct portions of the plurality of fibers are intertwined and follow correspondingly distinct directions.

32. A progressing cavity stator comprising:

a fiber reinforced composite component having a cylindrical axis, the fiber reinforced composite component providing an internal helical cavity, the fiber reinforced composite component having an internal surface, the internal surface having at least one helical groove provided thereon;

an elastomeric liner disposed on the internal surface; and

the fiber reinforced composite component including a plurality of fibers disposed in a matrix material, the plurality of fibers disposed such that distinct portions thereof follow correspondingly distinct directions.

33. The progressing cavity stator of claim 32, wherein the distinct portions of the plurality of fibers are intertwined and follow correspondingly distinct directions.

34. The progressing cavity stator of claim 32, wherein fibers among the plurality thereof are selected from the group consisting of fiber roving, woven fibers, non-woven fibers, braided fibers, braided fiber bundles, fiber bundles, fiber bundles wrapped in a braided fiber tube, chopped fibers, stitched three-dimensional fabrics, and combinations thereof.

35. The progressing cavity stator of claim 32, wherein fibers among the plurality thereof are selected from the group consisting of braided fibers and braided fiber bundles.

36. The progressing cavity stator of claim 32, wherein fibers among the plurality thereof are selected from the group consisting of glass fibers, carbon fibers, aramid fibers, boron fibers, polyester fibers, polyethylene fibers, and combinations thereof.

37. The progressing cavity stator of claim 32, wherein the matrix material comprises an epoxy resin.

38. The progressing cavity stator of claim 32, wherein the fiber reinforced composite component is deployed in a substantially cylindrical tool body, the tool body being substantially coaxial with the cylindrical axis of the fiber reinforced composite component.

39. The progressing cavity stator of claim 38, wherein the cylindrical tool body is couplable with a drill string.

40. The progressing cavity stator of claim 32, wherein the elastomeric liner has a non-uniform thickness, the non-uniform thickness varying in directions of at least one of parallel to the cylindrical axis and radially about the cylindrical axis.

41. A progressing cavity stator, wherein the progressing cavity stator is a product of the process comprising:

(a) providing a first core having at least one helical groove on an outer surface thereof;

5 (b) disposing a plurality of fibers in each helical groove to form a fiber preform;

(c) inserting the fiber preform into a cylindrical tube;

(d) injecting a resin into the cylindrical tube to form an impregnated fiber preform;

10 (e) removing the first core from the impregnated fiber preform thereby forming an internal helical cavity in the impregnated fiber preform;

(f) inserting a second core having at least one helical groove on an outer surface thereof into the internal helical cavity of the impregnated fiber preform, the second core having a smaller diameter than that of the first core, thereby forming a substantially helical annulus between the second core and the impregnated fiber preform;

15 (g) injecting an elastomeric material into the helical annulus; and

(h) removing the second core.

42. A downhole drilling motor comprising:

a progressing cavity stator including:

a substantially cylindrical tool body having a cylindrical axis;

5 a fiber reinforced composite component disposed in the tool body substantially coaxially with the cylindrical axis, the fiber reinforced composite component providing an internal helical cavity, the fiber reinforced composite component having an internal surface having at least one helical groove provided therein;

10 an elastomeric liner disposed on the internal surface of the fiber composite component;

the fiber reinforced composite component including a plurality of fibers disposed in a matrix material, the plurality of fibers being disposed such that distinct portions thereof follow correspondingly distinct directions; and

15 a helical rotor operational within the internal helical cavity of the progressing cavity stator;

43. The downhole drilling motor of claim 42, wherein the fiber reinforced composite component and the elastomeric liner form a progressing cavity insert, the progressing cavity insert having an outer surface sized and shaped for removable receipt within the cylindrical tool body.